IN VIVO FORMED THERMALLY CONTRACTED COLLAGEN TISSUE

Inventors: Hugh Sharkey and Gary Fanton

BACKGROUND OF THE INVENTION

~~Relationship to Copending Application~~

~~This application is a continuation of Application Serial No. 08/320,304, filed October 11, 1994, Serial No. 08/389,924, filed February 16, 1995, Application Serial No. 08/390,873, filed February 17, 1995, and Serial No. 08/637,095, filed April 24, 1996, each of which are incorporated herein by reference.~~

Field of the Invention

This invention relates generally to a composition of matter in a vascularized densely collagenous tissue or structure for changing the geometry of a collagen fibril containing tissue at the ultrastructural level structure by applying sufficient thermal energy to effect a cause a macroscopic change in the geometry of the tissue in order to effect a clinical result, and more specifically to a composition of matter where sufficient thermal energy is delivered to the collagen fibrils to increase their cross-sectional diameters, reduce their longitudinal lengths and maintain sufficient biomechanical properties of the vascularized collagenous tissue or structure.

Description of Related Art

Collagen containing tissue is ubiquitous in the human body and possesses several unique characteristics which are not found in other tissues. For example, collagen containing tissue provides the cohesiveness of the musculoskeletal system, the structural integrity of the viscera as well as the durability of integument. There are more than ten types of collagen molecules. Type I is the most common type of collagen found in bone, tendon, skin and other connective tissues. Type III is commonly found in muscular and elastic tissues.

The native conformation of the collagen protein molecules as well as the presence of covalent cross-links, both vitro and intermolecular, are responsible for providing densely collagenous tissues with the mechanical properties of high tensile strength and stiffness. Collagen connective tissue also possesses the unusual property of undergoing hydrothermal shrinkage at elevated temperatures. Hydrothermal shrinkage of collagen connective tissue at elevated temperatures is believed to occur due to the disruption of hydrogen bonds and salt links which are essential to maintain the native conformation of the collagen protein to about one-third of their original lineal distension. Additionally, the cross-sectional arch of the individual fibers increases greatly while maintaining adequate structural integrity of the connective tissue.

Thermal alteration of collagen has been performed to alter the topography of the cornea. For example, with regard to laser keratoplasty, near-infrared laser energy has been used to shrink collagen within the (avascular) cornea. U.S. Patent No. 4,976,709. Radio frequency (RF) electrical current has also been used to modify corneal topography. U.S. Patent Nos. 4,326,529 and 4.381,007. However, these patents do not provide for the treatment *in vivo* of vascularized collagenous tissue in the form of ligament or tendon structures.

One area in which densely collagenous tissues play an important role is in the stability of joints. Joint instability has long been recognized as a significant cause of disability and functional limitation in activities of daily living in additional to work and athletic participation. Diarthrodial joints of musculoskeletal system have varying degrees of intrinsic stability based on joint geometry and ligament and soft tissue investment. Diarthrodial joints are comprised of the articulation of the ends of bones and their covering of hyaline cartilage surrounded by a densely collagenous joint capsule. This joint capsule also maintains within the joint the synovial fluid that provides nutrition and lubrication of the joint surfaces. Ligaments can be either discrete isolated structures standing alone or may be represented by thickening or specific regions within a joint capsule. Ligaments junction to maintain joint stability by

restricting abnormal motion between two bones. Ligaments, tendons and joint capsules are all vascularized densely collagenous tissue.

Joint stability is maintained by the integrity of ligaments and, in some cases, the joint capsules. When a joint becomes unstable, its soft tissue restraints allow for excessive motion of the joint surfaces relative to each other both in magnitude and direction of translation. When one surface of a joint slides out of position relative to the other surface, but some contact remains, subluxation occurs. When one surface of the joint completely disengages and loses contact with the opposing surface, a dislocation occurs.

Some joints, due to their natural construction, are more prone to instability than others. For example, the shoulder (glenohumeral) joint, which provides the greatest range of motion of all joints, has long been recognized as having the highest subluxation and dislocation rate due to its inherent laxity relative to more constrained "ball and socket" joints, such as the hip.

The capsule of the shoulder consists of a synovial lining and three well defined layers of collagen fibrils. The fibers of the inner and outer layers extend in a coronal access from the glenoid to the humerus. The middle layer of the collagen fibrils extends in a sagittal direction, crossing the fibers of the other two layers. The relative thickness and degree of intermingling of collagen fibrils of the three layers vary with different portions of the capsule. The ligament components of the capsule are represented by abrupt thickenings of the inner layer with a significant increase in well organized coarse collagen fibril bundles in the coronal plane.

The capsule functions as a hammock-like sling to support the humeral head. In pathologic states of recurrent traumatic or multidirectional instability the capsule capacity is often increased. For the recurrent traumatic subluxor or dislocator, this increase in capsular capacity is felt to occur due to plastic deformation of the capsule. in the patient with multidirectional laxity, the capacious (redundant) capsule is felt to be congenital or developmental. In cases of congenital or developmental multi-directional laxity, an altered ratio of Type I

to Type III collagen fibers may be noted. In these shoulder capsules, a higher ratio of more elastic Type III collagen has been described.

Instability of the shoulder can occur congenitally, developmentally, traumatically or atraumatically and often becomes recurrent, necessitating surgical repair. In fact, subluxations and dislocations are a common occurrence and cause for a large number of orthopedic procedures each year. Symptoms of shoulder subluxations and dislocations include pain, joint instability, weakness, and limitation of function.

Surgical procedures have been developed for tightening capsular restraints that have become pathologically loose through the advancement and fixation of lax redundant capsular tissue. Surgical tightening of capsular restraints is classically performed through an open surgical approach which facilitates access to pathologically redundant tissue. Open surgical techniques, however, are associated with an increase in patient morbidity and generally require hospitalization.

Arthroscopic techniques have also been developed for tightening capsular tissue restraints by the advancement and fixation of capsular tissue. Arthroscopic techniques have the advantage of being performed through smaller incisions, with less patient morbidity and cost. As a result, arthroscopic techniques are usually less painful, performed on an outpatient basis, are associated with less blood loss and lower risk of infection, and have a more cosmetically acceptable scar. Recovery from arthroscopic techniques is often faster postoperatively than open surgical techniques. However, it is often more technically demanding to advance capsular or ligament tissue arthroscopically due to difficulties associated with current techniques. In addition, fixation of the shortened capsular tissue is more difficult arthroscopically than through open surgical methods.

In order to avoid the above difficulties associated with open and arthroscopic surgical techniques for tightening the capsular tissue, a need exists for a simpler, more controlled and effective method to reduce capsular volume.

The application of appropriate thermal energy needed to effect a shrinkage of the densely collagenous capsular tissue can accomplish this goal.

A need exists for a new composition of matter in vascularized densely collagenous tissue such as ligaments, tendons and joint capsular tissue. A further need exists for a composition of matter in vascularized densely collagenous tissue such as ligaments, tendons and joint capsular tissue with modified geometries of collagen fibrils while preserving adequate or sufficient biomechanical properties of the vascularized densely collagenous tissue such as ligaments, tendons and joint capsular tissue structure. Another need exists for a composition of matter in a vascularized densely collagenous tissue such as ligaments, tendons and joint capsular tissue characterized by modified geometries of collagen fibrils, maintenance of adequate or sufficient biomechanical properties of the vascularized densely collagenous tissue such as ligaments, tendons and joint capsular tissue and the generation for a scaffold for remodeling and/or addition of new collagen fibrils.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a composition of matter in a vascularized densely collagenous structure such as ligaments, tendons and joint capsular tissue.

Another object of the invention is to provide a composition of matter by applying sufficient and measurable thermal energy *in vivo* to a vascularized densely collagenous structure such as ligaments, tendons and joint capsular tissue to modify the geometry of collagen fibrils.

A further object of the invention is to provide a composition of matter by applying sufficient and measureable thermal energy *in vivo* to a vascularized densely collagenous structure such as ligaments, tendons and joint capsular tissue to modify the geometry of the collagen fibrils and achieve a clinical result while maintaining sufficient biomechanical properties of the vascularized densely collagenous structure.

Another object of the invention is to cause at the ultrastructrual level the desired macroscopic effect of tissue shrinkage in order to achieve a clinical result.

Another object of the invention is to provide a composition of matter in a vascularized densely collagenous structure such as ligaments, tendons and joint capsular tissue with modified geometries of collagen fibrils, a preservation of sufficient biomechanical properties of the vascularized densely collagenous structure, and the creation of a scaffold to initiate the remodeling and/or addition of new collagen fibrils.

Yet another object of the invention is to provide a composition of matter in a vascularized densely collagenous structure such as ligaments, tendons and joint capsular tissue to modify the geometry of collagen fibrils while applying thermal energy at a temperature of 80°C or less.

These and other objects of the invention are achieved in a new composition of matter in vascularized densely collagenous tissue structure performing a biomechanical function in a body, the collagenous tissue structure having been treated *in vivo* in the body with a measurable amount of thermal energy which increased a cross-sectional diameter of a collagen fibrils in the collagenous tissue structure and decreased a longitudinal length of the collagen fibrils and preserve at least a portion of the biomechanical function performed by the collagenous tissue structure in the body.

In one embodiment, a vascularized densely collagenous tissue structure is positioned within a portion of a body. The collagenous tissue structure has collagen fibrils which were treated *in vivo* in the body with a measurable amount of thermal energy to modify a geometry of the collagenous tissue structure and the portion of the body within which the collagenous tissue structure is positioned.

In another embodiment of the invention the composition of matter is a vascularized densely collagenous tissue structure positioned within a region of a body which naturally attaches a first portion of the body to a second portion of

the body. The collagenous tissue structure having collagen fibrils which were treated *in vivo* in the body with a measurable amount of thermal energy to modify a position of the first portion of the body relative to the second portion of the body.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1A illustrates a region of collagen tissue prior to contraction.

Figure 1B illustrates the introduction of an energy source into the body to contract the region of collagen tissue *in vivo*.

Figure 1C illustrates the region of contracted collagen tissue.

Figure 2A illustrates a ball and socket of a joint naturally interconnected by a region of collagen tissue

Figure 2B illustrates the ball and socket of the joint illustrated in Figure 2A having been brought together by contraction of the region of collagen tissue interconnecting the elements of the joint.

Figure 3 is a perspective view of the orthopedic apparatus of the present invention including the handle, trocar with deflected distal end, and electrode.

Figure 4 is a perspective view of the distal end of the trocar, with a layer of insulation partially removed from the distal end.

Figure 5 is a drawing of an orthopedic apparatus.

Figure 6 is a drawing of the right glenohumeral complex.

Figure 7 is a drawing of a loose joint capsule.

Figure 8 is a drawing of the apparatus of the invention supplying energy to a joint structure.

Figure 9 is a view of a disc positioned between two vertebrae.

Figure 10 is a drawing an electrode supplying energy to a herniated disc.

Figure 11 is an electromicrograph of cadaver tissue in a joint capsule, taken at 2 mm below the exterior tissue surface, at a position that is adjacent to a thermally treated area, illustrating cross-sections of collagen fibrils.

Figure 12 is an electromicrograph illustrating a longitudinal view of the collagen fibrils of Figure 11.

Figure 13 is an electromicrograph of cadaver tissue in a joint capsule taken 2 mm below the exterior tissue surface, at a position in a thermally treated area, illustrating cross-sections of collagen fibrils.

Figure 14 is an electromicrograph illustrating a longitudinal view of the collagen fibrils of Figure 13.

Figure 15 is an electromicrograph of cadaver tissue in a joint capsule taken 3-5 mm below the exterior tissue surface, at a position in a thermally treated area, illustrating cross-sections of collagen fibrils.

Figure 16 is an electromicrograph illustrating a longitudinal view of the collagen fibrils of Figure 15.

DETAILED DESCRIPTION

The present invention relates to a composition of matter in vascularized densely collagenous tissue structure performing a biomechanical function in a body. The collagenous tissue structure having been treated *in vivo* in the body with a measurable amount of thermal energy which increased a cross-sectional diameter of a collagen fibrils in the collagenous tissue structure and decreased a longitudinal length of the collagen fibrils and preserved at least a portion of the biomechanical function performed by the collagenous tissue structure in the body. This change is characterized by an increase in the collagen fibrils cross-sectional diameter and a shortening of their longitudinal length. The collagen fibrils geometry is changed to create a clinical result in the vascularized densely collagenous tissue structure and a functionality of a ligament or tendon structure is enhanced. In enhancing the functionality of the vascularized densely collagenous tissue structure, there is maintenance of sufficient biomechanical properties. In one embodiment, after application of the thermal energy there is a reduction of the biomechanical properties of the vascularized densely collagenous tissue structure which thereafter increases. The geometry of the

collagen fibrils in a vascularized densely collagenous tissue structure is altered collectively to change the geometry of the vascularized densely collagenous tissue structure while enhancing the functionality of the vascularized densely collagenous tissue structure. The biomechanical properties of the vascularized densely collagenous tissue structure are altered but the functionality of the tendon or ligament is enhanced. Application of thermal energy changes the conformation of the fibrils at the ultrastructrual level to effect a macroscopic shrinkage of tissue and also provides a scaffold for the remodeling and/or creation of new collagen, resulting in an enhancement of the function of the vascularized densely collagenous tissue structure. Additionally, a capacity for a healing response, e.g., laying down new collagen, is created in a vascularized densely collagenous tissue structure.

The application of the measurable thermal energy provides a substantially uniform histology of a contracted vascularized densely collagenous tissue structure.

The body may be, for example, a dog, cat, horse, cattle, and, more preferably a human being.

Application of the thermal energy changes the conformation of the collagen protein molecules from an extended organized conformation to a random coil, contracted conformation in order to achieve a macroscopic shrinkage along a longitudinal length of tissue. Collagen fibrils are treated with sufficient thermal energy to increase a cross-sectional diameter of the collagen fibrils, decrease a longitudinal length of the collagen protein molecules and produce a substantially uniform histology.

A variety of thermal energy sources are utilized including but not limited to RF, microwave, resistive heating, ultrasonic, liquid thermal jet and the like.

The geometry of the fibrils is modified by delivering thermal energy *in vivo* to the vascularized densely collagenous tissue structure at a temperature of 80 °C or less, preferably at a temperature in the range of 45 to 75 °C, more preferably at a temperature in the range of 50 to 70 °C and still more preferably

at a temperature in the range of 55 to 65 °C.

In one embodiment the collagen containing tissue is a ligament or tendon structure, and may be a collagen connecting tissue. The ligament or tendon structure can be a medial side ligament of the patella, a patellar tendon allograft, a patellar tendon autograft, or a connecting tendon.

Collagen connective tissue is ubiquitous in mammals and, in numerous instances, serves to interconnect portions of the mammal's body. According to the present invention, the composition of matter includes a region of collagen fibril tissue in a ligament or tendon structure which has been treated *in vivo* with an energy source which causes the thermal contraction of the collagen fibril containing tissue. The composition is created by applying measurable thermal energy from a thermal energy source to effect a clinical result. The vascularized densely collagenous tissue structure includes a plurality of collagen fibrils which have been treated *in vivo* with a sufficient and measurable amount of thermal energy to increase the cross-sectional diameter of the collagen fibrils, shorten their longitudinal length and enhance the functionality of the vascularized densely collagenous tissue structure.

As specified in this application, the contracted region of collagen fibril containing tissue is formed *in vivo*. *"In vivo"*, as the term is used in this application, refers to the formation of the contracted region of collagen fibril tissue within the body without exposing the region surgically, e.g., through an incision, or by removing from the collagen fibril tissue from the body, reducing the size of the collagen fibril tissue, and then reintroducing the contracted region. Rather, *in vivo* contracted collagen fibril tissue is collagen fibril tissue which has been reduced in size in a longitudinal direction by the application of measurable thermal energy while increasing a cross-sectional diameter of collagen fibrils and enhancing the function of the ligament or tendon structure.

For example, Figure 1A illustrates a region of collagen fibril tissue positioned within a body 3. As illustrated in Figure 1B, a thermal energy source

delivers measurable thermal energy 7 by an electrode probe 6 to contract the collagen fibril tissue 2 *in vivo* found in ligament or tendon tissue. The contraction occurs along a longitudinal axis of the collagen molecules. Application of measurable thermal energy to the collagen molecules increases a cross-sectional diameter of the collagen fibrils sufficiently which then causes a contraction of the collagen fibrils along its longitudinal axis. An incision is not made in the tissue immediately surrounding the region being contracted. As illustrated in Figure 1C when the collagen molecules are found in collagen connective tissue then the region of collagen fibril tissue draws the adjacent portions of the body 4, 5 into closer proximity.

The geometrically modified collagen fibrils are formed such that the ablation, e.g., cell death, the collagen fibrils containing tissue is minimal.

The degree to which the region of collagen fibril tissue has a geometric change is dependent on the function the region of contracted collagen fibril tissue is intended to perform. For example, where the region of contracted collagen fibril tissue is positioned within a joint and serves to tighten the interconnection between the elements of the joint, the degree of contraction that is desired is dependent on the severity of preoperative symptoms and condition of the joint at the time of arthroscopic inspection. The maximum degree of collagen fibril contraction that can be achieved is approximately two-thirds of its original structure.

In one embodiment of the invention, the composition of matter serves to tighten the interconnection between two portions of the body naturally joined by a region of collagen fibril connective tissue. As illustrated in Figure 2A, a ball 8 and socket 9 of a joint 11 are naturally interconnected by a region of collagen fibril tissue 13. As illustrated in Figure 2B, by contracting the region of collagen fibril tissue 13, the interconnection between the ball 8 and socket 9 of the joint is tightened. It is noted that, according to the present invention, the contraction of the region of collagen fibril tissue, and hence the tightening of elements of the joint is performed *in vivo*, i.e., without exposing the joint or disconnecting the

collagen fibril tissue and then reattaching the collagen fibril tissue. As a result, the effect of tightening the interconnection between two portions of the body is achieved without the need for an open surgical procedure.

According to this embodiment, the composition of matter is intended to encompass both the contracted collagen fibril tissue as well as any region of the body which includes two portions of the body which is connected by collagen fibril connective tissue which has been contracted in order to bring the two portions of the body into closer proximity with each other. Examples of anatomical locations in which the composition of matter of the present invention can be formed and used include collagen fibril containing ligament or tendon structures in connecting tissue, the shoulder, spine, cosmetic applications, a medial side ligament of the patella, a patellar tendon allograft, a patellar tendon homograft, a connecting tendon, a tibial condyle, a femoral condyle and cartilage strands coupled with a cartilage bed. It will be appreciated to those skilled in the art that the present invention has a variety of different applications, not merely those specifically mentioned in this specification. Some specific applications include joint capsules, specifically the gleno-humoral joint capsule of the shoulder, herniated discs, the meniscus of the knee, in the bowel, for hiatal hernias, abdominal hernias, bladder suspensions, tissue welding, DRS, and the like.

In one embodiment, the thermally contracted collagen fibril tissue is attached to a joint such that contraction of the collagen fibril restricts soft tissue elasticity and improves joint stability.

In one embodiment, the thermally contracted collagen fibril tissue is attached to a shoulder joint such that contraction of the collagen fibril reduces redundancy of the shoulder capsule and improves joint stability. When applied to the shoulder, there is capsular shrinkage of the glenohumeral joint capsule of the shoulder and a consequent contracture of the volume, the interior circumference, of the shoulder capsule to correct for instability symptoms.

Figure 3 illustrates an orthopedic apparatus which may be used to contract collagen fibril containing tissue in orthopedics, including but not limited to ligaments, joint capsules and connective tissue includes a handpiece 10. The orthopedic apparatus provides for the controlled modification of the geometry of collagen fibrils in a ligament or tendon structure, increased cross-sectional diameters and decreased longitudinal lengths of the collagen fibrils while the structural properties of the ligament or tendon structure is sufficiently maintained without significant cell necrosis. The orthopedic apparatus of the present invention is used for a controlled modification of collagen fibrils geometries. Energy is delivered from the thermal energy delivery surface, (hereafter referred to as "electrode") to a collagen fibril tissue site. The orthopedic apparatus provides a means for moving the electrode in conformance with the geometry of the collagen fibril tissue site. A handle design of the orthopedic apparatus provides physician control of the movement of the electrode to closely approximate a desired collagen fibril containing tissue site. This is readily achieved with the use of only one hand.

Handpiece 10 includes a trocar 12 with an elongated body and a longitudinal axis 14. A trocar distal end 16 is laterally deflectable about longitudinal axis 14. Trocar 12 also includes a proximal end 20. In one embodiment, trocar has a 9F outer diameter.

An electrode 20 is positioned at trocar distal end 16. In one embodiment, electrode 20 has an outer diameter of 13F. Electrode 20 is capable of delivering substantially uniform energy across an energy delivery surface 22 to an area of collagen fibril tissue. This results in collagen fibril geometric changes.

Controlled geometric changes to the collagen fibrils is assisted with the controlled and measurable delivery of measurable thermal energy. The design of electrode 20 is selected to enhance the level of controlled delivery which is preferably under feedback control. In one embodiment, electrode 20 has no sharp edges where measurable thermal energy is delivered. This reduces the delivery of measurable thermal energy and the creation of hot spots which lead

to tissue ablation instead of collagen fibril geometry modification along a longitudinal axis, and an increase in collagen fibril cross-sectional area.

Electrode 20 has a backside 24 that can be covered with an insulating layer. Use of the insulating layer permits the physician to more accurately control delivery of energy to the intended tissue. In many orthopedic procedures electrode 20 must be moved back and forth, in a painting manner, along the collagenous tissue surface. Often, the backside 24 of electrode 20 is adjacent to tissue which is not treated. Therefore, in order to reduce the possibility of ablating the tissue which should not be treated, it is beneficial to provide backside 24 with a layer of insulation so that energy is not delivered from backside 24. The inclusion of an insulating layer to backside 24 can also provide electrode 20 with radiused edges. This is achieved by physically eliminating sharp edges on electrode 20.

Handpiece 10 also includes a handle 26 attached at proximal end 18. A coupler 27 can be included to couple handle 26 to trocar 12. Trocar 12 can extend into an interior of handle 26. Handle 26 includes an actuating member 28 and a locking member 30. The positions of actuating and locking members 28 and 30 can vary. However, it is preferred that actuating member 28 and locking member 30 be positioned on an exterior surface of handle 26 on opposing sides. The physician can then use one hand; the thumb for one and a finger for the other. This provides physician control of trocar distal end 16 and electrode 20 so that collagen fibril containing tissue is not ablated and there is minimal, if any, cell necrosis; instead the collagen fibril containing tissue is contracted to a desired state. Actuating member 28 is generally an elongated structure which is pivotally mounted to handle 26. The physician pulls on the end of actuating member that opposes the end which is mounted to handle 26. Actuating member 28 has a resting position when it is closest to handle 26. As actuating member 28 is pulled away from the resting position it moves to one or more activation positions cause trocar distal end 16 to become deflected

(articulated). The more actuating member 28 moves away from its resting position, the more trocar distal end 16 is deflected.

Locking member 30 also has a resting position, and a locking position that locks deflected trocar distal end 16 in place. Locking member 30 is releasable from its locking position to its resting position, or to an intermediate position, and holds the activation position of actuating member 28 when the deflection of trocar distal end 16 is adjusted. Handle 26, with associated actuating member 28 and locking member 30, is particularly suitable for use with one hand to easily adjust the amount of deflection of trocar distal end 16.

Actuating member 28 can be directly coupled or indirectly coupled to trocar 12. The same is true with locking member 30. Positioned at a proximal end of handle 16 is a cable connector 31.

A shrink tube 32 surrounds trocar 12, leaving electrode 20 exposed.

Referring now to Figure 4, trocar 12 can be covered and surrounded by an insulation layer 34 which extends to electrode 20. Insulation layer 34 can extend to electrode backside 24. Trocar distal end 16 is laterally deflectable relative to longitudinal axis 14. Deflection can be achieved by a variety of different means including but not limited to segmenting trocar distal end 16, serrating trocar distal end 16, the use of a steering wire (not shown) that extends internally or externally from handle 26 to distal end 16, as well as other methods well known to those skilled in the art. All of trocar 12 may be made of a memory metal or only trocar distal end 16 can be made of a memory metal.

As shown in Figure 5, orthopedic apparatus 36 includes handpiece 12, an energy source 38 and a cable 40 coupled to handpiece 12 and energy source 38.

In one specific embodiment of the invention, joint capsules are treated to eliminate capsule redundance. More specifically, orthopedic apparatus 36 is used to contract collagenous tissue in the glenohumeral joint capsule (Figures 6, 7 and 8). When applied to the shoulder, there is a capsular shrinkage of the glenohumeral joint capsule of the shoulder, and a consequent contracture of the volume, the interior circumference, of the shoulder capsule to correct for

instability symptoms. The degree of capsular shrinkage is determined by the operating surgeon, based on the severity of preoperative symptoms and the condition of the capsule at the time of arthroscopic inspection.

Handpiece 10 includes trocar 12 that is deflectable but it is also spring loaded. This permits handpiece 12 to be introduced into the shoulder in a straight position, percutaneously or non-percutaneously. The physician begins working and begins to deflect trocar 12 in order to reach a selected tissue site. There may be a series of deflection steps needed in order to reach the tissue site and begin to apply energy to the collagenous tissue. The trocar is deflected to a first position, then to a second, perhaps back to the first position and to a non-deflected position, and electrode 20 is painted back and forth, up and down a collagen fibril tissue site. Articulating and locking members 28 and 30, and electrode 20 with radiused edges, permits the controlled delivery energy in order to contract the collagen fibril tissue and not ablate the tissue. Articulating and locking members 28 and 30 provide the physician with sufficient control to vary the position of electrode 20 in both difficult and easy access areas, in order to provide controlled delivery of energy to contract collagen fibril tissue and minimize ablation. Without articulating and locking members 28 and 30 there is insufficient control of energy delivery to provide controlled ablation. The combination of the two provides a ratcheting effect and free articulation and movement of electrode 20 along a desired collagen fibril tissue surface.

Figures 9 and 10 illustrates the use of handpiece 10 with discs of the spine.

EXAMPLE 1

A shoulder capsule of a human cadaver in a water bath is used to contract collagen fibrils in the shoulder capsule along their longitudinal axis and increase a cross-sectional diameter of collagen fibrils. An RF electrode coupled to an RF energy source is used to deliver measurable RF thermal energy to the

joint capsule and create a contraction of collagen containing tissue. 4 Watts of energy is supplied. The RF thermal energy is delivered from a distal end of the RF electrode. The RF electrode is moved by the physician with painting strokes. Sufficient and measurable RF thermal energy is delivered to change the geometry of the collagen fibrils without ablation or significant cell necrosis. The longitudinal length of the collagen fibrils containing tissue is reduced, producing a contraction; while the cross-sectional diameter of the collagen fibrils is increased. The functionality of the tissue structure is enhanced. Figure 11 and 12 illustrate the electromicrographs of the collagen fibrils at a site adjacent to where the thermal energy is delivered. Figures 11 and 12 serve as a good base line for comparison and illustrate collagen fibrils where the geometry has not been modified by the delivery of thermal energy. All electromicrographs were taken at x24,000. In Figure 12 the electromicrograph shows characteristic periodical cross-striations of untreated collagen.

EXAMPLE II

A shoulder capsule of a human cadaver in a water bath is used to contract collagen molecules along its longitudinal axis and increase a cross-sectional diameter of collagen fibrils in the shoulder capsule. An RF electrode coupled to an RF energy source is used to deliver measurable RF thermal energy to the joint capsule and create a contraction of collagen containing tissue. 4 Watts of energy is supplied. The RF thermal energy is delivered from a distal end of the RF electrode. The RF electrode is moved by the physician with painting strokes. Sufficient and measurable RF thermal energy is delivered to change the geometry of the collagen fibrils without ablation or significant cell necrosis. The longitudinal length of the collagen fibrils containing tissue is reduced, producing a contraction; while the cross-sectional diameter of the collagen fibrils is increased. RF energy is delivered to a the shoulder capsule and Electromicrographs taken at 2mm depth. In Figure 13, at 2 mm the collagen fibrils had increased cross-sectional diameters, decreased longitudinal lengths

with a loss of distinct edges but visible fine structures are apparent. In Figure 14 there is a loss of cross-striations and increased collagen fibril diameters. The functionality of the collagen fibril containing tissue is enhanced. The delivery of measurable thermal energy provides a substantially uniform histology of the composition.

EXAMPLE III

A shoulder capsule of a human cadaver in a water bath is used to contract collagen molecules along its longitudinal axis and increase a cross-sectional diameter of collagen fibrils in the shoulder capsule. An RF electrode coupled to an RF energy source is used to deliver measurable RF thermal energy to the joint capsule and create a contraction of collagen containing tissue. 4 Watts of energy is supplied. The RF thermal energy is delivered from a distal end of the RF electrode. The RF electrode is moved by the physician with painting strokes. Sufficient and measurable RF thermal energy is delivered to change the geometry of the collagen fibrils without ablation or significant cell necrosis. The longitudinal length of the collagen fibrils containing tissue is reduced, producing a contraction; while the cross-sectional diameter of the collagen fibrils is increased. In this example thermal energy, RF, was delivered to a the shoulder capsule and Electromicrographs taken at 3 - 5 mm depth. Figure 15 is a Electromicrograph taken at 3 to 5 mm deep in the treated area. An increased collagen fibril cross-sectional diameter is observed, the longitudinal length is decreased and the functionality of the ligament or tendon structure is enhanced. Figure 16 shows a loss of cross-striations and increased fibril diameters. At this depth, the histology is not substantially uniform.

The foregoing description of a preferred embodiment of the invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Obviously, many modifications and variations will be apparent to practitioners skilled in this

art. It is intended that the scope of the invention be defined by the following claims and their equivalents.

What is claimed is: